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by Yu. P. Neprochnov
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CSO; 3681-N/b

MEASUREMENTS OF THE PROPAGATION VELOCITY OF ELASTIC WAVES IN LOOSE SEA DEPOSITS

[This is a translation of an article written by Yu. P. Neprochnov and G. B. Udintsev in Izvestiya Akademii Nauk SSSR (News of the Academy of Sciences USSR), Geophysical Series, No. 11, 1959, pages 1699-1701.]

Information on the rate of propagation of elastic waves in loose sea sediments that cover the bottom of the sea is of great interest in connection with the interpretation of data of marine experimental seismology. As a rule, the data on marine seismic-acoustic sounding [1] make it possible to estimate the velocity of propagation of elastic waves only in relatively deep levels of sedimentation layers (method of refracted waves) or on the averaged values of the velocities for stacks of surface layers (method of reflected waves). There are known experiments of laboratory measurement of the velocity of propagation of sound in samples of bottom sediments [2, 3]. However, when using the results of the laboratory measurements, the question arises of their corresponding to the velocities of sound which do take place in natural conditions, on the bottom of seas and oceans. It is therefore of interest to investigate the possibility of measuring the velocity of sound in bottom sediments directly on the bottom of the sea.

The Institute of Oceanology of the Academy of Sciences USSR has carried out experiments on the determination of velocities of propagation of elastic oscillations in loose bottom sediments both under laboratory conditions (in samples taken from the bottom with the aid of soil tubes), as well as directly on the bottom of the sea. The results obtained make it possible to judge the actual velocities of the sound on the surface layers of the loose bottom sediments.

The first series of expedition was carried out in 1957 on the expedition vessel "Vityaz" in the Japanese Sea. The second series was performed in 1957 -- 1958 on the Black-Sea experimental-scientific research station of the Institute of Oceanology in the Black Sea.*

To investigate the velocity of elastic oscillations in specimens of bottom deposits under laboratory conditions, a

*Participating in the work were I. B. Andreyeva, V. M. Kovilin, and M. F. Mikhno.

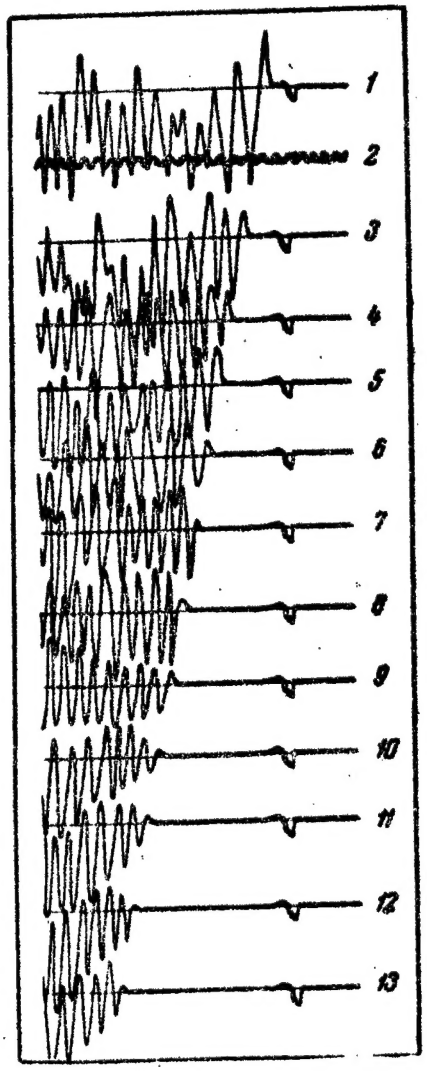

Fig. 1
Oscillograms obtained in the measurement of the velocity of propagation of elastic oscillations in a sample of loose bottom sediments with the aid of the UZS-2 ultrasonic seismoscope by the profilling method.

slightly modified ultrasonic seismoscope was used, developed in the Institute of Earth Physics of the Academy of Sciences USSR. [4].

The measurements of the velocity of propagation of elastic oscillations are carried out with this instrument by measuring the time of arrival of ultrasound pulses in a specimen of known length. The profiling procedure used in the

investigation of the samples of bottom sediments, previously used for the investigation of samples of metal [5], has made it possible to increase substantially the accuracy of the measurement, since it is different to determine length of the investigated specimen and the exact time of the first arrival of the waves passing through the loose sediments. The time was measured not on the basis of the first arrivals of the waves, which were not sufficiently clear, but by the first phase of the waves. A series of measurements was made in each sample 10 - 15 cm long, with length intervals of approximately 1 cm with the radiator kept stationary and the receiver being shifted. The series of oscillograms obtained thereby makes it possible to draw an averaging curve, the slope of which determines the average velocity of propagation of the elastic oscillations in the sample (Fig. 1). The error of measurement of linear intervals between the positions of the shifted receiver did not exceed 0.1 mm. After making the measurements in a sample of loose bottom sediments, calibration measurements were made by means of the same method in distilled water. A comparison of the results obtained in the calibration measurements with the calculated values of the velocity of sound in the water gives grounds for assuming that the measurement error in this method is of the order of $\pm$ 1.6 percent.

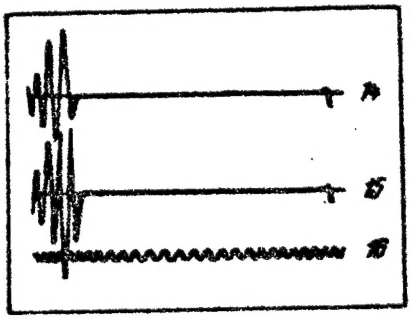

Fig. 2
Oscillograms obtained in measuring the velocity of propagation of elastic oscillations with the aid of the bottom installation.

To measure the velocity of sound directly on the bottom of the sea, a special installation was developed, representing a stand with a rigidly mounted transmitter and receiver of ultrasonic signals. The transmitter and receiver (Rochelle salt crystals) were included in metallic wedge-shaped knives imbedded in the bottom sediments by the weight of the stand. The receiver was equipped with a preamplifier with a separate power supply, contained in a steel balloon, which could withstand the water pressure at great depth. The transmitting-

receiving installation was connected by means of a RK-50 high frequency cable with the ultrasonic seismoscope, located on the ship, and could be dropped to the bottom of the sea for the measurement. The base between the transmitter and the receiver at first amounted to 20 cm, and then was increased to 50 cm in order to increase the accuracy of the measurements. To obtain control samples of the bottom sediments, the equipment was provided with a small soil tube.

During the experiment, the installation was dropped to the bottom. Before reaching the bottom, approximately at a distance of 100 -- 50 meters from the surface, a calibration measurement of the velocity of sound in water was made. The installation was then mounted on the bottom, and the knives with the transmitter and receiver of ultrasonic systems cut into the bottom sediments. The measuring oscillogram was obtained, and then the calibration measurement in the water was repeated. To obtain the exact value of the velocity of sound in the water, hydrogeological observations were made at the depth of the calibration measurement, and the velocity of sound was calculated from the temperature and from the salinity. The calibration measurements were used to estimate the value of the time markers, generated in the seismoscope, and then to calculate the running time of the ultrasound pulse in the bottom sedimentation.

An example of an oscillogram obtained in the measurement of the velocity of propagation of elastic oscillations in loose sediments with the aid of the bottom installation is shown in Fig. 2. Here the upper oscillogram corresponds to the measurement of the velocity of sound in the water, the middle one to the velocity in the bottom sediments, and the lower one gives time markers generated in the seismoscope. The transmitters were imbedded at a depth of 50 cm, the measurement base was 507 mm. The apparent oscillation frequency in the pulses is on the order of 50 kcs. It was determined from the accuracy of the readings of the distance and of the time, and also from the convergence of repeated measurements, that the error in the velocity of the elastic oscillations in the ground, as measured with the bottomming apparatus, did not exceed $\pm$ 1.0 percent.

To compare the results obtained by different methods, the velocity of propagation of elastic oscillations was measured in the laboratory for samples of bottom sediments, taken with the end of a soil tube. Since the problem of the influence of the pressure and temperature on the velocity of propagation of elastic oscillations in loose bottom sediments has hardly been investigated, the influence of these factors in the comparison of the results of the laboratory and bottom measurements has not been taken into account.

During the experiments, columns of bottom sediments in the Japanese and Black Seas were investigated, as well as those

in the open regions of the Pacific Ocean. The measurements by means of the bottomming installation were carried out only in the Japanese and Black Seas, and the principal number of measurements was carried out in the Black Sea. Principally investigated were clay, siltone-clay, and siltstone silt. The values obtained for the velocity of sound in the bottom sediments fluctuate from 1430 to 1620 meters per second. It is interesting to note that in certain cases the velocity of sound in the bottom deposits is found to be less than the velocity of sound in water. This confirms the data of certain seismic investigations on the existence of surface layers of bottom sediments with a small velocity of propagation of elastic oscillations [6].

A comparison of the results has shown in general good agreement between the data of the laboratory and bottomed measurements of velocity of propagation of elastic oscillations for depths up to 100 meters. The greatest discrepancy in this case reached 5 percent. For example, for one of the stations for a clay silt, at a depth of approximately 50 meters, a value was obtained of 1620 meters per second for the velocity of sound, whereas the measurements under laboratory conditions of the sample, the velocity of sound was found to be only 1520 meters per second.

These results must be taken into account when using materials of the laboratory measurements of the velocity of sound in samples of bottom sediments. Such measurements are of interest for the clarification of the diagenetic changes, which are experienced by the sedimentation material, and also for the study of the gradient of sound velocity in the sediment layer. To obtain precise absolute values of the velocity of propagation of elastic oscillations in loose bottom sediments it is necessary that the bottoming apparatus be used.

Academy of Sciences USSR
Institute of Oceanology

Received 19 February 1958

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